AD-A221 062

Technical Report 1326
December 1989

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Integrating Environmental Products into the Combat Direction System

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ADMINISTRATIVE INFORMATION

The study covered in this document was performed from October 1987 – September 1989. It was conducted for the Office of the Chief of Naval Research, under funding provided by the Office of Naval Technology, Arlington, VA. Specifically, this funding was under program element 602435N, project no. RM35G80, and accession no. DN488760. The work was performed by Code 431 of the Naval Ocean Systems Center (NOSC), San Diego, California.

Released by
D. G. Mudd, Head
Combat Direction
Systems Branch

Under authority of
G. F. Chandler, Head
Afloat Command Centers
Division

ACKNOWLEDGMENT

The prototype displays were programmed by the Block 1 main contractor, Hughes Aircraft Company. Environmental data was supplied by the Naval Oceanographic Office, and additional information was supplied by SPAWAR PMW 141.

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SUMMARY

OBJECTIVE

This report documents an investigation of Combat Direction System (CDS) requirements for environmental data. The goal of this investigation was to (1) determine the most important functional areas of the CDS that would be enhanced by environmental data and (2) research possible implementations of these enhancements in tactical displays.

RESULTS

The CDS requirements were thoroughly reviewed, and three environmentally sensitive tactical decision aids were chosen for inclusion into the CDS. The areas picked for detailed research involve air tracking, surface and subsurface tracking, and ownship susceptibility to missiles.

RECOMMENDATIONS

The three tactical decision aids selected were recommended for inclusion into the earliest version of the CDS allowed by schedules and funding.

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INTRODUCTION

During recent years, we have been investigating methods of integrating natural environmental data into a Combat Direction System (CDS). This report summarizes some of the principles and goals of integrating environmental data into a CDS. It also provides a high-level description of some results of this research and describes them generically so future designers of CDSs will have a foundation for including environmental data into their systems. (For more information on this, and other research, refer to the Reference and Bibliography chapter at the end of this report.)

The CDS is the **realtime** warfighting command control system for a major surface combatant; it is used by both force-level and ownship-level commanders in the ship's Combat Information Center (CIC). As such, the CDS needs realtime information on

1. The tactical situation.
2. The state of ownship assets (or battle group assets, if being used by a force commander).
3. The natural environment in which the ship has to operate.

The goal of this research was to explore ways of meeting the last requirement in consonance with the first two.

GOALS

USERS OF ENVIRONMENTAL DATA

The question is — which users of the CDS could actually use environmental data in all the various formats (refer to the paragraphs under Methods of Integrating Environmental Data for a description of *how* environmental data integrates with tactical data and displays) and all the various displays. The following can be stated a priori:

1. The environment affects almost all of the concerns of CDS personnel, since all weapons, sensors, communication systems, and even in some cases the ship's survival, depend upon the natural environment in which the ship and its assets are located.
2. Some CDS functions must be carried out with minimum regard to fine details because of time and cost constraints.

Thus, the problem becomes one of prioritizing the functions of the CDS, with respect to the effect of the natural environment. All CDS functions are eligible (item 1, above), but a threshold exists below which it will not be practical to worry about the environment (item 2, above). The CDS functions were reviewed (Parker, 1987) with the following results. The top three (general, environmentally sensitive) CDS functions can be prioritized as follows:

1. Detection and tracking of aircraft.
2. Detection and tracking of surface and subsurface targets.
3. Determining susceptibility to incoming missiles

These were the most likely areas affected by the environment for which knowledge of the environment could be used to significantly improve the CDS function. As such, the users of the associated environmental data would be the TAO, air trackers, subsurface trackers, and the air resource and intercept personnel (see figure 1 for CDS operators).

Other functional areas could be improved by using environmental knowledge, but were not now deemed sufficiently profitable to investigate (the payoff, in the opinion of CDS engineers and Navy personnel, would not be large enough to warrant undergoing the *current* implementation problems). However, subsystems, such as sensors and weapons control, would make greater use of environmental data. Since the primary purpose of CDS is to manage the ownship organic tactical data and to enact the commands of the CIC personnel, the CDS concerns itself only with the effect of the environment on some *asset* which it controls or monitors.

Note that any single implementation which integrates environmental data in a CDS for a particular hull will be different from others, because of different missions (e.g., CG vice CV). However, beyond that, some optimizing could be done, since different ships would be expected to operate in different environmental conditions. Such detailed optimization will not be examined here, due to the time and cost constraints of the required research. (The actual builder of the CDS for a particular hull would be the one to consider these options.)

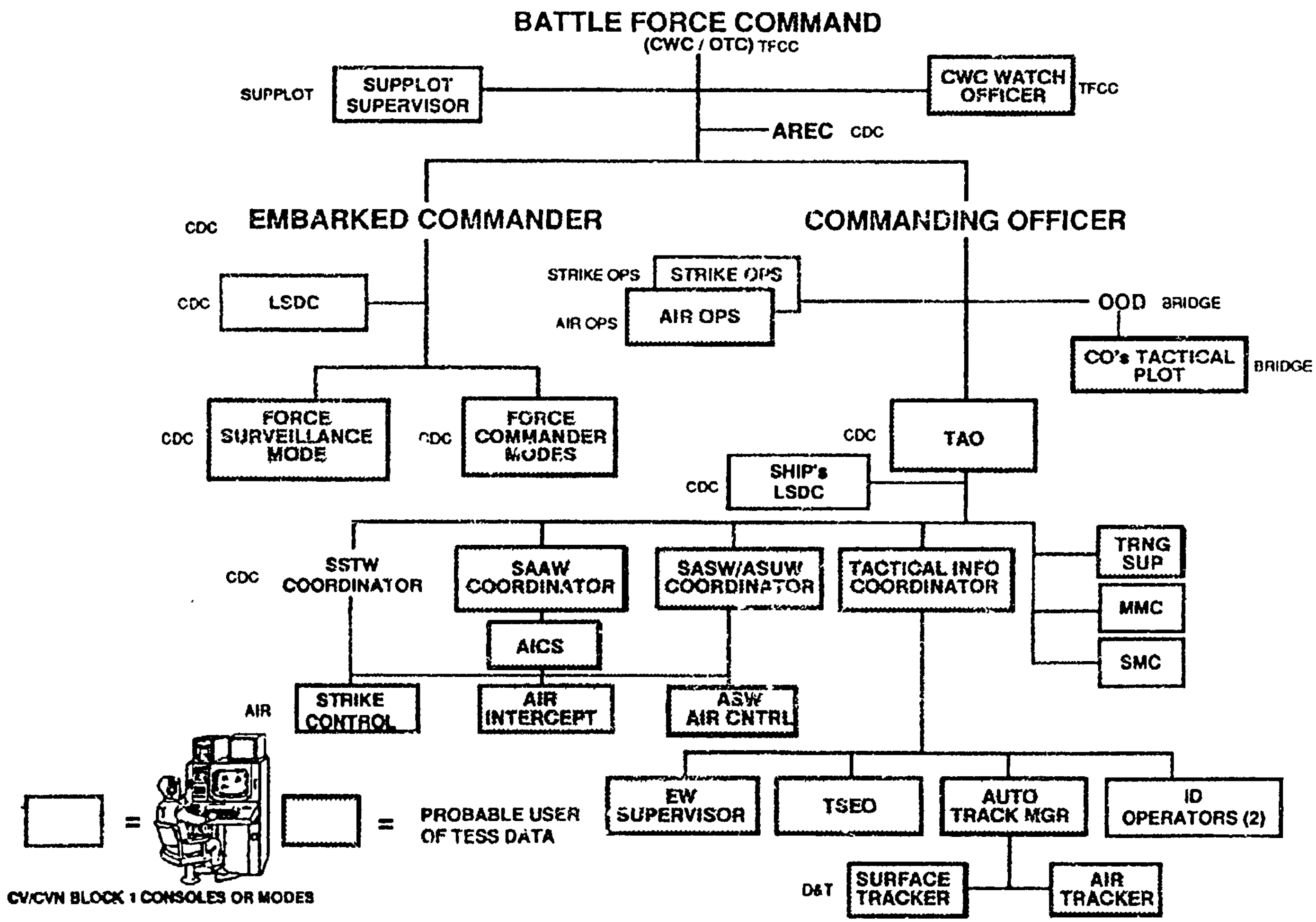

Figure 1. ACDS Block 1 personnel hierarchy.

METHODS OF INTEGRATING ENVIRONMENTAL DATA

Principles

Integration of environmental data into a CDS is most visible when the tactical displays (also called Force Graphics Displays [FGDs]), not the hardware, but the picture on the screen, are altered to better convey the picture of reality that the environmental data gives. However, some uses of environmental data in a CDS are not immediately evident to the end user. The last two paragraphs in this chapter discuss these uses in more detail.

The most important principles in integrating environmental data into CDS displays are

1. Do **not** present the user more information than he can readily handle (that is, within the realtime constraints of the command decision, e.g., 1 second).
2. Do not present the user with information that could mislead him.
3. Information presented to the user must relate directly to the asset the user is controlling or observing.

Unprocessed Data Displays

"Unprocessed" means not processed by *the CDS*. That is, the environmental data itself may go through many computers and many formats, but the data is still taken *in toto* by the CDS, and has not been manipulated and hidden in another display. For example, a satellite picture would be considered unprocessed data by the CDS. While displays showing unprocessed data can be useful to some, since they do not show impacts upon the combat system assets, such displays would be of minimal value to most of the CDS operators. As such, these types of displays were not investigated further.

Processed Data Displays

When the environmental *data is displayed in relationship to some combat system asset, then we call it a processed data display*. This was deemed the type of integration of environmental data that would have the biggest payoff, so we spent most of our time developing such force graphics displays. (The more important results are shown in the next chapter under Sample Displays.).

The purpose of these FGDs is to enable appropriate tracking personnel (or even the TAO) in the CIC to (1) improve their understanding of how well they can perceive their target, or (2) position their asset(s) to improve their condition for dealing with imminent danger (such as incoming missiles).

In all these cases, note that the environmental data (e.g., radar coverages or acoustical coverages) does not need much interpretation by the user to relate the environment to the asset of interest; the processed displays use concepts with which he is already familiar, such as coverages, zones, etc. This is different from the unprocessed data (in the previous paragraph) where the user would have to analyze the environmental data to find relevance.

Modified (Implicit) Tactical Displays and Functions

A third general way of using environmental data in a CDS is where the environment measurements, *per se*, are invisible to the CDS personnel, but nevertheless have been included in some algorithmic calculation or in some simple tactical display.

An example would be Harpoon missile coverages, which nominally are described by a circular disk. The environment may actually distort the missile coverage from being perfectly circular. This new oddly shaped coverage may be displayed to the user, without him being aware which particular environmental data did what to the coverage; he only knows he sees the most accurate picture of the real coverage.

SYSTEMS FOR ENVIRONMENTAL DATA

We assumed that whatever environmental data the CDS needs could be obtained from onboard sources. The source was assumed to be a tactical environment support processor (e.g., the Tactical Environment Support System, TESS(3)*). Whatever the source, the underlying goal is that the required data should be delivered within the *realtime* framework of the CDS. That is, the addition of environmental data should not slow down the function of the CDS nor overwhelm the user, either from waiting for data across an interface or from delays arising from not following the first principles outlined in the earlier paragraph, Principles.

The CDS-TESS interface was investigated further. The significant result of the study was that the volume of data across the interface called for a CDS to implement a SAFENET-type interface, and that the CDS and TESS communities needed to create some sort of data compression scheme or other methods to reduce the amount of data across the interface. Transmitting significant environmental data (e.g., radar coverages) over the tactical links (e.g., Link 11, Link 16) was shown to be unfeasible with current implementations of the links.

*Tactical Environment Support System (3), Type A Specification, SPAWAR PMW 141.

RESULTS

The more important results are presented here, with both sample displays and some data requirements. All these displays are recommended for inclusion in future versions of CDSs.

SAMPLE DISPLAYS

We used a prototype version of ACDS Block 1 to develop some prototype displays of the "processed" kind discussed earlier. These prototype displays allowed us to review our ideas in an appropriate surrounding. One conclusion was that color definitely aids in displaying large-coverage diagrams. (The CDS community believes that color displays are required when large volumes of data must be given to the user.) This is particularly true when one is painting the screen with vertical radar coverages, for the lobes of the radar (if painted green like everything else on a monochrome display), effectively blot out relevant tactical data.

Furthermore, presenting the effects of the environment to the CDS operator requires much operator interaction. That is, besides the FGDs on the main video display terminal, a user must enter data and direct how (and when) he wants to see the data. Therefore, the implementer must determine the best method the user should employ for accessing the FGD he wants. For example: Should the variable function keys (VFKs) be used? Should the alphanumeric display (above the graphics terminal) be queried? Or should the 6-by-7 panel be used? To choose the correct data entry option, the implementer must consider how quickly the user needs the data or how "user friendly" to make the FGD. These points are all very important when the FGD must be used in realtime with actual threats. (We used a very rough interface for the prototype displays, based on the VFKs and the Character Readout [CRO] display above the main CRT.)

We developed prototypes of three major FGDs on the ACDS Block 1 prototype under development at NOSC. The first FGD is an integration of the tactical picture with radar coverage. The second similarly uses radar coverages, but overlays incoming missile profiles. The third is an integration of acoustical data with CDS Block 1's automated doctrine capabilities. These displays were then reviewed by Navy personnel (former CIC personnel) and CDS engineers. *The sensor coverages in the displays are nominal; i.e., they are meant to be typical of what a user would see and are not calculated coverages of actual sensors.*

Figure 2 shows a CDS tactical display (with an operator) which would be used for the FGDs in an implementation. Note the various entry devices and display devices noted above. We used such a display for prototyping the environmental FGDs.

Radar Refractive Effects and Tactical Picture

This display (figure 3) is an adaptation of the type popularized by IREPS. Here, the user (an air tracker or an air resource controller) will be able to see how well his radars are covering the space he is monitoring. The coverages (in some form) are expected to be available from TESS and downloaded to the CDS, either on demand (requiring a high-capacity interface) or downloaded by TESS aperiodically (whenever significant changes occur in the coverage).

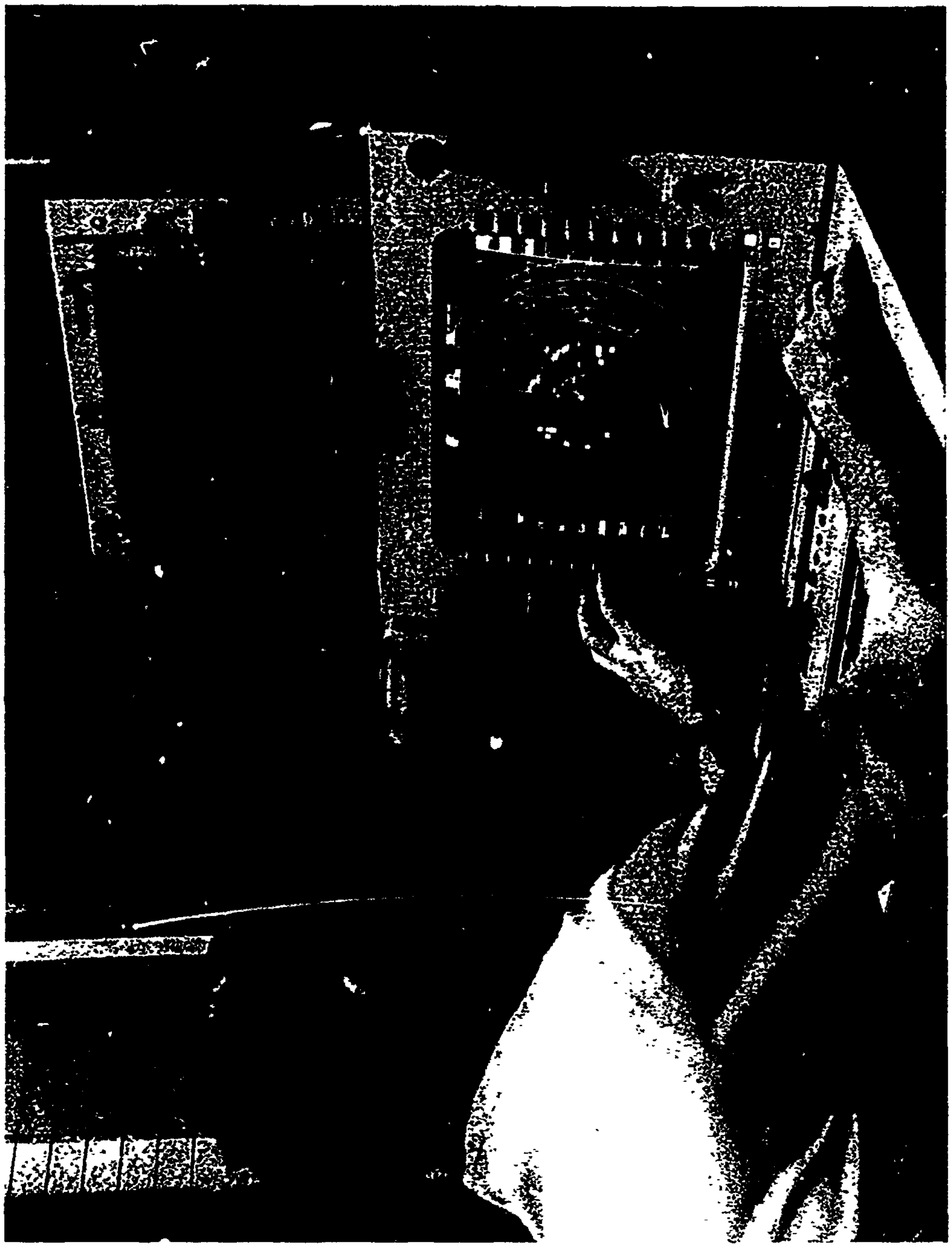

Figure 2. CDS tactical display.

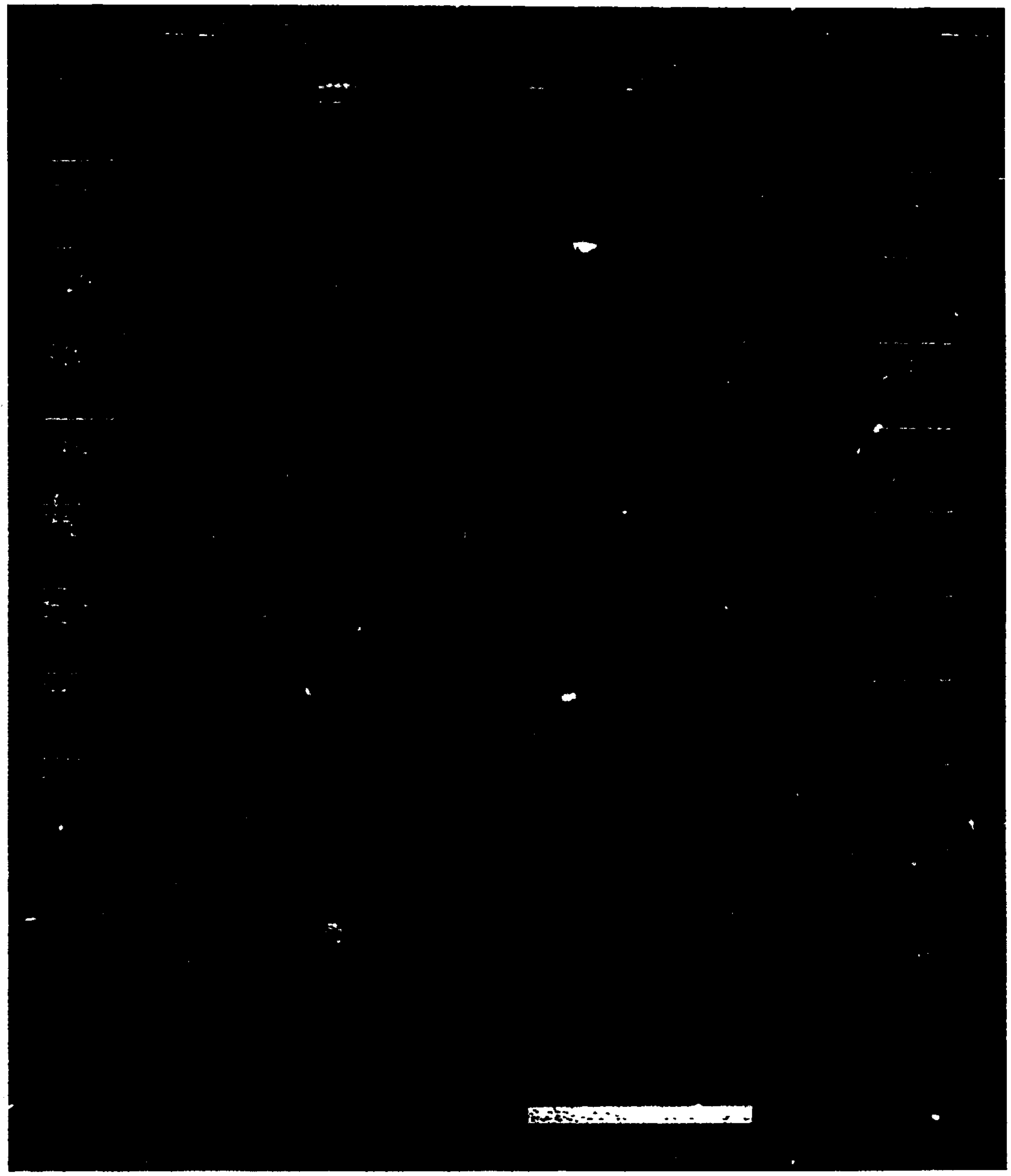

Figure 3. Radar refractive effects integrated with a tactical picture (nominal radar coverage).

The user would be sitting at his PPI (Planned Position Indicator) and would pop up this FGD for two main reasons:

1. Tracks are dropping for no apparent reasons (or tracks are indicated by the CDS as being extrapolated).
2. To position assets (such as an E2-C) to maximize the use of assets when preparing for an engagement.

The user would then determine how he could reposition some assets to address the problem. This display is expected to be used frequently.

Notice from the photo that we also investigated various pattern fills to see if the user would prefer some method other than solid color (as in figure 4). We were concerned that painting large sections of the operator's PPI with solid colors for coverages would decrease the user's ability to follow the realtime tracks. The results were inconclusive, but those who reviewed the displays preferred the solid fill (as in figure 4) over the pattern fill (of figure 3).

Radar Refractive Effects and Missile Profile

This force graphic display (figure 4) is an extension to the previous FGD. Now an additional overlay is added to show possible incoming-missile profiles. Such missile profiles would be available from an intelligence library maintained by the CDS.

The user would bring this FGD up on his display when he believes his ownship (or asset) is vulnerable to incoming missiles; this usually would depend on many factors during operations. The operator has the flexibility to select the radar type as well as the opposing missile type (the figure is based on a generic missile). The decision maker will then have several options to take if he believes he has too low a probability of detecting incoming missiles. Of course the radar coverage calculations must be timely!

Acoustic Zones and CDS Doctrine

A more sophisticated integration of environmental data into the CDS is shown in figure 5, an FGD supporting ASW. While the actual display may look simpler to the user than the previous two, the CDS is deeply involved in algorithmic processing. The goal is to optimize the positions of the battle-force sensors in the existent environment.

Here an acoustically interesting (e.g., bottom bounce, convergence zones) area is displayed with the tactical data at the operator's console. Given the graphical display of the area of interest, the operator can see subsurface tracks and his own ASW units which may possibly exploit the specific environmental conditions. *Furthermore*, starting with ACDS Block 1, the CDS will have sophisticated doctrine (e.g., "if X then do Y" type of processing) in which this type of acoustic data can be used. For example, the acoustic zone in figure 5 can be used as a type of *doctrine zone* in the CDS doctrine processing. In this case, an instruction can be given (perhaps significantly preceding the actual use of the FGD) to the CDS to alert the operator (by making the track symbol larger, or blink, etc.) when certain types of tracks leave or enter the acoustical zone. *As such, the CDS supplements the operator with automated use of environmental data.*

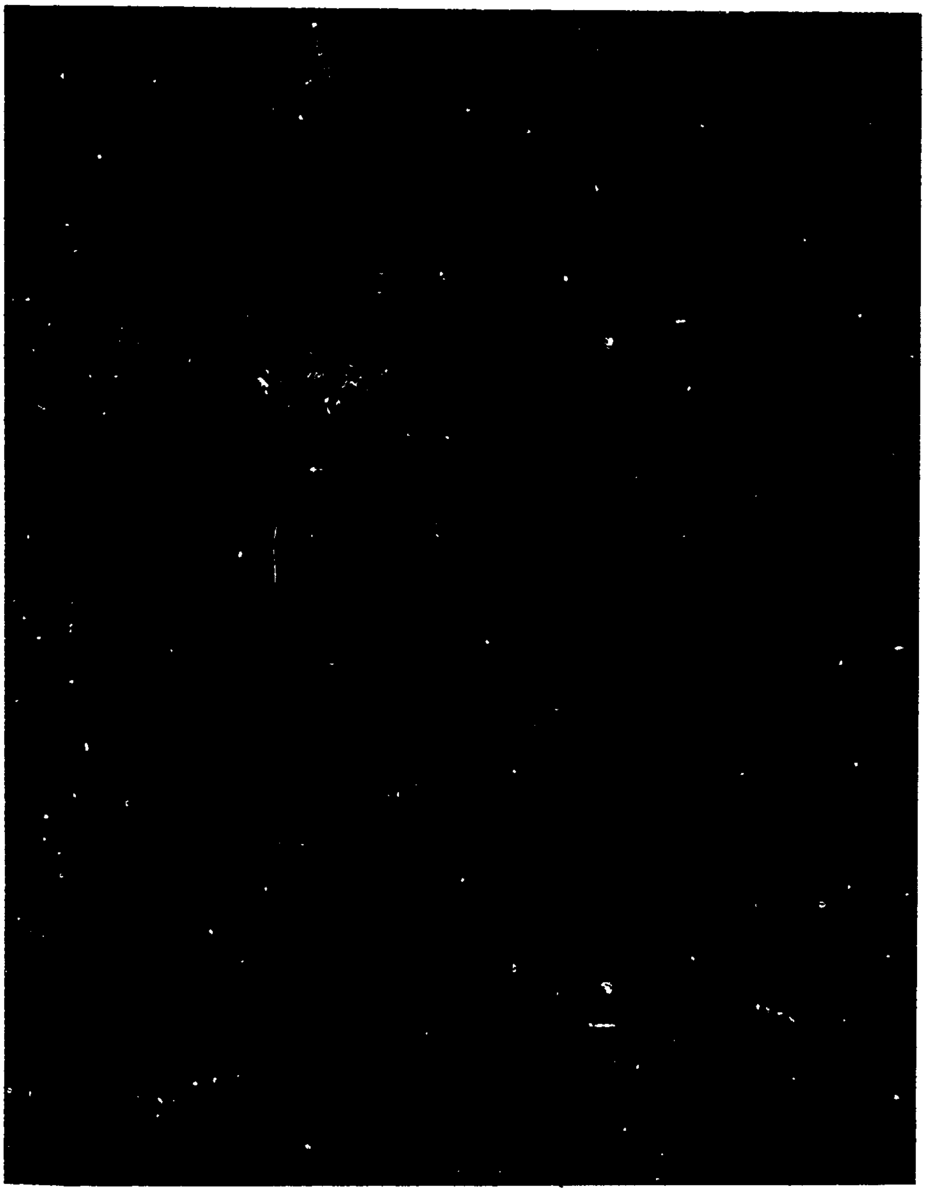

Figure 4. Radar refractive effects integrated with a missile profile (nominal radar coverage).

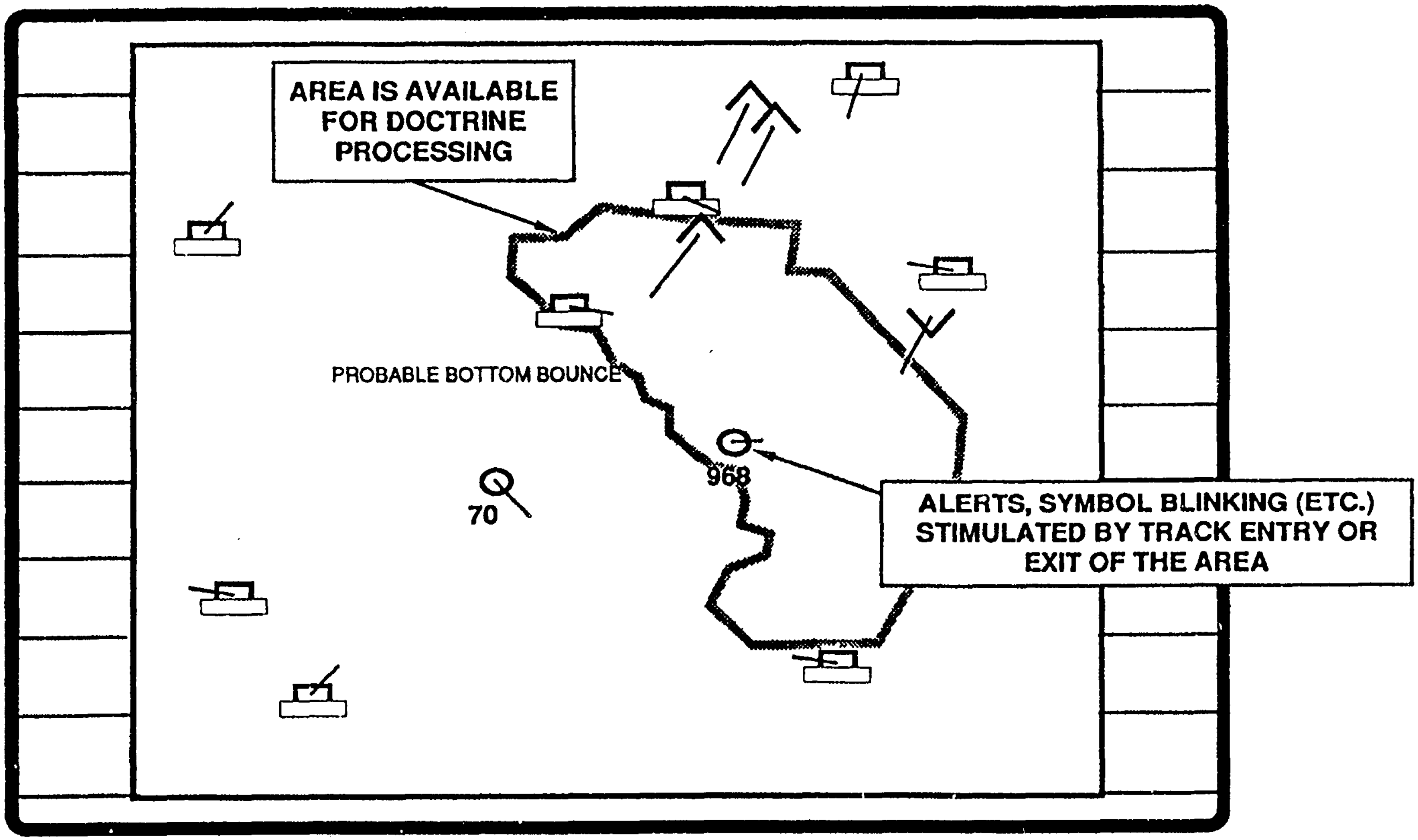

Figure 5. ASW area display.

This type of FGD, of course, depends very heavily upon dynamically updating the locally and recently measured environmental data. Even when the data would be from historical sources, the operator's ownship may be moving and will need updates. TESS is assumed to have all this data available.

ENVIRONMENTAL DATA USEFUL TO CURRENT CDS

The previous three FGDs will require realtime or near realtime data from a source external to the CDS. This source is expected to be TESS(3) and its follow-on versions. The types of environmental data the CDS requires for these previous FGDs will be

1. Radar coverages (2D and 3D, surface and air).

2. Areas of anomalous acoustic characteristics.

A more detailed investigation of required environmental parameters was conducted in conjunction with the interface study mentioned in an earlier paragraph, entitled Systems for Environmental Data.

APPLICATION TO FUTURE SYSTEMS

The FGDs proposed as a result of this research are appropriate to versions of CDSs after the engineering development model version of ACDS Block 1. By then (1992), TESS(3) will be onboard several major surface combatants. Future variants of ACDS Block 1 will be ideal for these types of FGDs; the ideas also apply to smaller ship CDSs, though the question will be: "Where to get the environmental data?" (TESS(3) is currently scheduled only for CVs, BBs, and LHDs.) As the FGDs discussed in this report make their way into the fleet (on CVs) in the middle 1990s, the usefulness of these types of displays is expected to generate requirements for similar FGDs on smaller ships (CGs). Even smaller ships (FFGs) may require highly specialized environmental data integration, which we recommend as a subject for future research.

CONCLUSIONS

We investigated the requirements of the CDS for environmental data and determined which of the most important functional areas of the CDS to further research (air tracking, surface and subsurface tracking, and ownship susceptibility to missiles). We researched prototype displays for these areas we deemed most important (and feasible), as shown in figures 3, 4, and 5. Based on reviews of these display ideas by Navy personnel and CDS engineers, our conclusion is that these three tactical decision aids should be implemented in the earliest version of the CDS that schedules and funding will allow.

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APPENDIX A

ABBREVIATIONS AND ACRONYMS

ACDS	—	Advanced Combat Direction System (specific program nomenclature for CDS systems)
BB	—	Battleship
Block 1	—	The first versions of ACDS to offer significant functionality improvements (such as Link 16, automated doctrine, etc.) over its predecessor the Naval Tactical Data System
CDS	—	Combat Direction System, generic term for the ownship and organic realtime command control system
CDC	—	Combat Direction Center (a.k.a., CIC)
CIC	—	Combat Information Center
CRT	—	Cathode Ray Tube
CV	—	Aircraft Carrier
FGD	—	Force Graphics Display, the graphical decision aids on CRTs output by ACDS
FFG	—	Frigates
IREPS	—	Integrated Refractive Effects Prediction System, the precursor to the FGDs experimented with in this effort
TAC	—	Tactical Action Officer
TESS(3)	—	Tactical Environment Support System, version 3
TFCC	—	Tactical Flag Command Center
VFK	—	Variable Function Keys, a means of user input into ACDS

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1 AGENCY USE ONLY (Leave blank)	2 REPORT DATE	3 REPORT TYPE AND DATES COVERED
	December 1989	Final: October 1987 – September 1989

4 TITLE AND SUBTITLE	5 FUNDING NUMBERS
INTEGRATING ENVIRONMENTAL PRODUCTS INTO THE COMBAT DIRECTION SYSTEM	PE: 602435N PR: RM35G80 WU: DN488 760
6 AUTHOR(S) S. H. Edwards	
7 PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Ocean Systems Center San Diego, CA 92152-5000	8 PERFORMING ORGANIZATION REPORT NUMBER NOSC TR 1326
9 SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Technology 800 N. Quincy St. Arlington, VA 22217-5000	10 SPONSORING/MONITORING AGENCY REPORT NUMBER

11 SUPPLEMENTARY NOTES

12a DISTRIBUTION/AVAILABILITY STATEMENT	12b DISTRIBUTION CODE
Approved for public release; distribution is unlimited.	

13 ABSTRACT (Maximum 200 words)

Several uses and methods were researched for incorporating natural environmental data into the Combat Direction System (CDS). After an extensive review of CDS requirements, three tactical decision aids were selected for inclusion into the next available version of the CDS. These decision aids are (1) integrated radar coverage (with the effects of the environment) with the tactical picture; (2) the same as the previous decision aid, but with missile profile overlays; and (3) integration of accustic zones (with environmental effects) with CDS doctrine and the tactical picture.

14 SUBJECT TERMS		15 NUMBER OF PAGES
propagation assessment environmental data	command and control tactical decision aids	22
		16 PRICE CODE

17 SECURITY CLASSIFICATION OF REPORT	18 SECURITY CLASSIFICATION OF THIS PAGE	19 SECURITY CLASSIFICATION OF ABSTRACT	20 LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED